Leading the way

Photoinitiators for LED Curing
**LED Light Sources**

**Light Sources:**
- **Mercury lamps**
  - Medium Pressure Mercury Lamp
  - Doped Mercury Lamps
- **LED Lamps**
  - 365 nm
  - 385 nm
  - 395 nm

**Far UV**
- 200-240nm
  - Short wave UV
  - Surface cure

**UV C**
- 240-280nm

**UV B**
- 280-320nm
  - Medium wave UV
  - High speed

**UV A**
- 320-400nm
  - Long wave UV
  - Depth cure

**Near Vis**
- 400-450nm
  - UV-Vis
  - Depth cure

Source: Phoseon
Advantages & Disadvantages

LED lamp technology becoming increasingly important in modern energy curing

**Advantages**
- Reduced cost/energy of running lamps
- No warm up time. On/Off lamps
- No ozone generation
- Cold cure
- Improved safety
- Long bulb lifetimes compared to mercury

**Disadvantages**
- Few spectral outputs
- Low power lamps
- Few photoinitiators appropriate
- Yellowing often a problem
- Difficult to achieve effective surface cure

Formulation must be adapted to account for change in lamp technology
Oxygen Inhibition

Overcoming Oxygen Inhibition

Photoinitiators:
- Higher concentrations
- Combinations of PIs

Amines:
- Aromatic amines or acrylated amines

Resin selection:
- High functionality
- Polyether acrylates

Physical methods:
- N₂ inertion
- Lamination
- Waxes
- High viscosity

A competing, undesired reaction to polymerization in free radical UV cure.
# Type I: Phosphine Oxides

<table>
<thead>
<tr>
<th>Photoinitiator Name</th>
<th>Structure</th>
</tr>
</thead>
<tbody>
<tr>
<td>SpeedCure TPO-L</td>
<td><img src="image1.png" alt="Structure" /></td>
</tr>
<tr>
<td>SpeedCure TPO</td>
<td><img src="image2.png" alt="Structure" /></td>
</tr>
<tr>
<td>SpeedCure BPO</td>
<td><img src="image3.png" alt="Structure" /></td>
</tr>
<tr>
<td>SpeedCure XKm</td>
<td><img src="image4.png" alt="Structure" /></td>
</tr>
</tbody>
</table>

**Features:**
- Depth Cure
- Long wave UV absorbance
- Photobleaching
- SpeedCure XKm also has Type II functionality (hybrid)

**Applications:**
- Thick coatings
- Composites & CIPP
- TiO$_2$ pigmented coatings
- Adhesives
# Type I: Benzil Ketal

<table>
<thead>
<tr>
<th>Photoinitiator Name</th>
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</tr>
</thead>
<tbody>
<tr>
<td>SpeedCure BKL</td>
<td><img src="image" alt="Structure" /></td>
</tr>
</tbody>
</table>

**Features:**
- General purpose
- Short wave UV absorbance
- Very fast rate of cleavage
- High thermal stability
- Some yellowing and odour

**Applications:**
- Clear and pigmented coatings
- Adhesives
- Styrene or unsaturated polyester based coatings
Type I: Aminoacetophenones

<table>
<thead>
<tr>
<th>Photoinitiator Name</th>
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</tr>
</thead>
<tbody>
<tr>
<td>SpeedCure BDMB</td>
<td><img src="image1" alt="Structure" /></td>
</tr>
<tr>
<td>SpeedCure 97</td>
<td><img src="image2" alt="Structure" /></td>
</tr>
</tbody>
</table>

**Features:**
- Mid range absorption
- Depth and surface cure
- Sensitized by SpeedCure ITX

**Applications:**
- High speed inks
- Electronics
- Etch resist
- Solder mask
# Type II: Benzophenones

<table>
<thead>
<tr>
<th>Photoinitiator Name</th>
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</tr>
</thead>
<tbody>
<tr>
<td>SpeedCure BMS</td>
<td><img src="image" alt="SpeedCure BMS Structure" /></td>
</tr>
<tr>
<td>SpeedCure PBZ</td>
<td><img src="image" alt="SpeedCure PBZ Structure" /></td>
</tr>
<tr>
<td>SpeedCure EMK</td>
<td><img src="image" alt="SpeedCure EMK Structure" /></td>
</tr>
</tbody>
</table>

### Features:
- Mid to long wavelength absorption
- Surface and depth cure
- High reactivity
- SpeedCure EMK can also act as an amine synergist and sensitizer

### Applications:
- Pigmented systems
- LED Curing

![Absorbance Graph](image)
# Type II: Thioxanthones

<table>
<thead>
<tr>
<th>Photoinitiator Name</th>
<th>Structure</th>
</tr>
</thead>
<tbody>
<tr>
<td>SpeedCure ITX</td>
<td><img src="image1.png" alt="Structure" /></td>
</tr>
<tr>
<td>SpeedCure DETX</td>
<td><img src="image2.png" alt="Structure" /></td>
</tr>
<tr>
<td>SpeedCure CPTX</td>
<td><img src="image3.png" alt="Structure" /></td>
</tr>
</tbody>
</table>

## Features:
- Long wavelength absorption
- Depth cure
- Photoinitiator & sensitizer
- Used with amine synergist
- Yellowing

## Applications:
- Pigmented systems
- LED curing
- Cationic sensitizer

![Absorption Graph](image4.png)

**Absorbance**

**Wavelength / nm**

- Speedcure 2-ITX
- Speedcure CPTX
- Speedcure DETX
Amines act synergistically with Type II photoinitiators and have other important roles such as, oxygen scavenging, solvency and affecting water uptake in ink formulations.

Care should be taken when formulating to avoid acidic environments which may neutralize the amine and inhibit reactivity.

In water-based systems low pH should be avoided as this can reduce the reactivity of the amine synergist.
Amine Synergists

<table>
<thead>
<tr>
<th>Product Name &amp; Chemistry</th>
<th>Structure</th>
<th>Features</th>
</tr>
</thead>
<tbody>
<tr>
<td>SpeedCure EDB Aminobenzoate</td>
<td><img src="image" alt="Structure" /></td>
<td>Solid. Very fast cure. Suitable for offset litho inks.</td>
</tr>
<tr>
<td>SpeedCure EHA Aminobenzoate</td>
<td><img src="image" alt="Structure" /></td>
<td>Liquid, easy to incorporate. Less reactive than SpeedCure EDB. Suitable for flexo inks.</td>
</tr>
</tbody>
</table>

**SpeedCure Amine synergists are predominantly based on aminobenzoate chemistry:**

Aminobenzoates are much more reactive than simple tertiary amines and exhibit lower “bloom”.

Aminobenzoates are insoluble in water and so are suitable for lithographic applications where water/ink balance is critical.
With offices and facilities in England, Europe, India, China, Japan and America we offer a truly Global Supply Network.

Thank you for your attention Questions?